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Western Ecology Division

Research Update

Corvallis, Oregon 97333 EPA /600/F-05/018 September 2005

WED teams up with National Park Service to quantify contaminants in remote places

With North America's highest mountain, 20,320-foot Mount McKinley, in the background, researchers filter 50-liter water samples in Wonder Lake, Denali National Park.

National parks exist to preserve the Nation's most beautiful scenery and pristine ecosystems for the appreciation of future generations. Park managers can protect parks' plants and animals from obvious and direct threats by making and enforcing rules and regulations, but airborne pollutants do not recognize laws or park boundaries.

North America's wild high-altitude, high-latitude places are particularly vulnerable to airborne anthropogenic contaminants because some of these pollutants possess physical properties that cause them to accumulate preferentially in the earth's colder places. This "cold fractionation" phenomenon is known to occur with some forms of semi-volatile organic compounds such as polychlorinated biphenyls (PCBs), hexachlorocyclohexane (HCHs), and mercury, thus making high-elevation and high-latitude ecosystems more vulnerable to accumulation of these pollutants.

The National Park Service (NPS), EPA, and other agencies established a multi-year research effort, the Western Airborne Contaminants Assessment Project (WACAP), to determine the risk from airborne pollution to ecosystems and food webs in western national parks. Organized and implemented by NPS's Air Resources Division, the project involves the cooperation of dozens of scientists from NPS, EPA, U.S. Geological Survey, USDA Forest Service, and several universities. Dixon H. Landers, Research Environmental Scientist at the Western Ecology Division (WED) serves as scientific director for the project as well as principal investigator of WACAP sediment research. The project was implemented in 2002 and will conclude in 2007 with an interpretive report. NPS and EPA can use the WACAP results to evaluate risk to high-elevation and high-latitude ecosystems in the West from atmospherically transported contaminants.

The project is documenting the adverse effects of atmospheric transport of anthropogenic pollutants in some of the nation's most remote, and presumably pristine, places. Airborne contaminants can pose a serious health risk to wildlife and humans. Some toxins tend to "biomagnify," that is, small concentrations in air, water, snow, and plants can result in larger concentrations higher in the food web such as in fish and mammals.

WACAP research is centered on eight national parks, extending from Gates of the Arctic National Park and Preserve and Noatak National Preserve in arctic Alaska to Rocky Mountain National Park in Colorado and Sequoia National Park in California. At each of these parks, WACAP researchers have selected two small, high-elevation lake catchments as locations for sampling to determine which airborne contaminants have been deposited there.

WACAP scientists are measuring a broad suite of persistent organic pollutants such as PCBs, DDT, DDE, HCHs, and HCB. Although many of the contaminants have been banned in the United States, they are still used in other parts of the world. Chemicals in current use that are being assessed include pesticides and flame retardants. Mercury is of special interest and is being analyzed in all samples except water.

A WACAP team samples snow on Mount Rainier in Washington.

In northern Alaska, such as at Buriel Lake in Noatak National Preserve, WACAP researchers employed aircraft to reach study sites and to ferry out their samples.

How do these contaminants reach such pristine, protected places? An important component of WACAP is to examine the atmospheric transport of chemicals. Already substantive information about the movement of contaminants has been compiled. Evidence from multiple sources indicates that both current-use and banned chemicals are present in national parks.

Specific examples of the project's findings: dacthal, a herbicide to control certain weed grasses in a variety of food crops including those in the tomato, cabbage, and melon families, is found in much higher concentrations in Sequoia National Park and Rocky Mountain National Park, which are near agricultural regions, than in Mount Rainier National Park or parks in Alaska. By contrast, the project found hexachlorocyclohexanes, a family of persistent pesticides banned or phased out by the United States, in Noatak National Preserve, and in Mount Rainier, Glacier, Sequoia, and Rocky Mountain National Parks.

Scheduled field sampling is about two-thirds complete. Indicators being sampled and their purposes include:

- Snow. Measure of direct atmospheric loading of snow which represents 50–90 percent of the annual precipitation in many alpine sites, with annual sampling in 2003, 2004, and 2005.
- Fish. Provide a direct measurement of food web impacts and food web bio-accumulation. In 2003, scientists sampled fish from five lakes in Sequoia, Rocky Mountain, and Olympic National Parks and in 2004 they sampled fish from four lakes in Alaska. Besides contaminant loads, the fish were analyzed for endocrine disruption, physiological impairment, and other indicators.
- Water. Measure the presence of water-soluble chemicals.
- Lake sediment. Used to determine the decennial-scale histories of contamination by semi-volatile organic compounds (SOCs) and metals. Sediments are being dated by lead isotope technology, which is useful for determining the age of deposits back 200 years.

Sediment analysis provides information on naturally occurring metals as well as on the accumulation of many anthropomorphic pollutants.

- Lichen. Because they are highly sensitive to oxides of sulphur and nitrogen, precursors of acidic deposition, lichens are widely used environmental indicators. Lichen provides a direct measure of food web impact and accumulation of metals.
- Vegetation. Collected at different altitudes in all 19 parks, provides information on ecosystem exposure and comparisons among parks.
- Moose meat. In Alaska, moose tissue sampled in 2004 provides a measure of exposure to people who are subsistence hunters there.

Working beside a lake in an Alaskan wilderness park, researchers dissect a fish to evaluate condition and possible impacts of contaminants.

Protocol for snow sampling requires a great deal of shoveling.

WACAP is analyzing how atmospheric contaminants reach the national parks. A primary goal of the atmospheric transport component of the study is to illustrate movement of air masses from all source regions that may be affecting the western national parks. Air masses from agricultural regions in California, Mexico, and Canada could explain contaminants in some parks. However, because there is strong and persistent west-east flow of air masses at the latitude of all the parks, significant amounts may be coming from distant western sources in Asia and Europe.

Scientists are using a model of atmospheric transport to follow likely trajectories of contaminants back to their possible sources. By mapping where an airmass has traveled during the past 10 days, the researchers can see if it has passed over a region known to be a source of pollution. The model contains atmospheric data going back five years.

Data from the project and references to related research are being posted on the Internet for scientists to use. Two years of mercury concentration data from snowpack samples are currently available. These reveal spatial patterns in mercury concentration. In the Alaskan samples, the concentrations tend to be quite variable, a likely effect of the shallow depth of snowpacks at low-elevation inland sites and relatively large amounts of wind-blown crustial material in the snowpack. Along the west coast of the contiguous 48 states, most of the parks had a fairly low concentration of mercury, while inland sites, Glacier and Rocky Mountain National Parks, had a higher concentration, presumably related to higher concentrations of particulate matter there. Additional data are being posted as they become available.

Collecting lichen samples from Alaskan tundra.

A WACAP researcher operates the lake sediment sampler.

WACAP is headed by Chris Shaver and Tamara Blett of the National Park Service's Air Resources Division in Denver. In addition to Landers, scientific director and sediment principal investigator, the project involves the following principal investigators: Don Campbell, USGS, snow; Linda Geiser, USDA Forest Service, vegetation; Daniel Jaffe, University of Washington, atmospheric transport; Michael Kent and Carl Schreck, Oregon State University, fish; Staci Simonich, Oregon State University, semi-volatile organic compounds; and Howard Taylor, USGS, metals.

Dr. Landers is also involved with Canadian colleagues on a related study being conducted in Canada's high and remote places. Eventually data from sediment cores he and colleagues obtained in high-altitude Canadian lakes will be compared with data collected in the U.S. parks. (Contact D.H. Landers, 541-754-4427; landers.dixon@epa.gov)

A special inflatable raft is used for the sediment coring device, shown being prepared by Dr. Dixon Landers.

Research Briefs

Cost-effective benthic sampling protocol for ecological risk assessment

Habitat-based ecological risk assessments rely, in part, on knowledge of the relative ecological indicator values of the habitats at risk. An optimal benthic macrofaunal sampling is the most cost-effective combination of sample unit size (area and depth), sieve mesh size, and number of replicate samples. As part of a programmatic effort to estimate estuarine habitat values with respect to ecological indicators of benthic macrofaunal community condition, WED scientists determined the optimum benthic macrofaunal sampling protocol for detecting differences between four major habitats (eelgrass, cordgrass, mud shrimp, and ghost shrimp) in Willapa Bay, Washington. They studied four important ecological indicators (number of species, numerical abundance, total biomass, and fish and crab prey abundance). In their paper, published in the journal *Estuaries*, the WED scientists identify the optimum sampling protocol and show how ecological indicator values for habitats accurately estimated using the optimum sampling protocol can be used to translate measured or predicted changes in habitat areas into their large-scale ecological effects (Contact: Steven Ferraro, 541-867-4048; ferraro.steven@epa.gov).

Reference: Ferraro, S.P., and F.A. Cole. 2004. Optimal benthic macrofaunal sampling protocol for detecting differences among four habitats in Willapa Bay, Washington, USA. Estuaries 27:1014-1025. WED-02-138

Also, see a feature article on this paper in Coastal and Estuarine Science News, January 2005, Volume 27, Number 6, "Better, Faster, Cheaper Benthic Sampling" at http://erf.org/cesn/vol27n6.html

Streamlined fish tissue mercury-sampling analysis procedure saves money and fish

When testing fish for mercury, scientists conventionally have relied on independent analysis of both filet samples and whole fish. Now WED scientists have established a filet biopsy/direct mercury analysis procedure that is precise and accurate for determining mercury concentrations in fish filets and for predicting whole-fish mercury concentrations.

Mercury contamination of fish is a widespread phenomenon with potential impact on human health as well as on the health of wildlife. Because people eat the muscle tissue of fish and because wildlife tend to eat whole fish, EPA has an interest in both filet and whole-fish mercury concentrations. Evaluation of mercury contamination of fish over widespread areas, as is required for regional assessments, is hindered by the reluctance of agencies to grant collection permits, by the need for freezer space to store whole fish, and by labor-intensive preparation of whole-fish samples. The mercury sampling method evaluated by Research Scientist Spencer Peterson, Environmental Statistician John Van Sickle, and colleagues at WED, involves non-lethal 0.25 gm fish filet biopsy samples taken in a manner not expected to kill the fish being analyzed. Using these procedures, the researchers studied mercury concentrations in 210 fish of various species and sizes from 65 sites across 12 western states. The researchers found a highly significant relationship between mercury levels in the biopsy samples and whole fish (r^2=0.96). When this tissue sampling and analysis procedure is combined with probability-based sampling, the results can be inferred to an entire population of water bodies, thus providing regional contamination estimates with known confidence levels. The study was recently published in the journal *Archives of Environmental Contamination and Toxicology*. Dr. Peterson presented results of the research at international conferences in Kyoto, Japan, and Victoria, British Columbia. (Contact: S.A. Peterson, 541-754-4457; peterson.spencer@epa.gov.)

Reference: Peterson, S.A., J. Van Sickle, R.M. Hughes, J.A. Schacher, and S.F. Echols. 2005. A biopsy procedure for determining filet and predicting whole-fish mercury concentration. Arch. Environ. Contam. Toxicol. 48(1):99-107. WED 04-035

Study aids understanding of the impact of increased CO_2 on forests

Trees rely on a system of fine roots and associated fungi to take up required nutrients from the soil. To learn how fine tree roots respond to elevated levels of carbon dioxide, WED scientists recently published results of a four-year study using ponderosa pine trees grown under controlled conditions in open-topped chambers. Following a protocol that enhanced statistical reliability, they applied three different levels of carbon dioxide (CO_2) and three different levels of nitrogen to the pines. David Tingey, Senior Research Plant Pathologist, and his WED colleagues report in a recent article in the journal *Trees* that elevated levels of CO_2 increased the extent that fine roots of the ponderosa pines extended into and used new soil. Higher CO_2, however, had no effect on associated root fungi. By contrast, nitrogen fertilizer had no effect on the growth of fine roots, but nitrogen increased the amount of mycorrhizal fungi and the extent to which the trees used areas of the soil containing these fungi. (Contact D.T. Tingey, 541-754-4621; tingey.dave@epa.gov)

Reference: Tingey, D.T., M.G. Johnson, and D.L. Phillips. 2005. Independent and contrasting effects of elevated CO_2 and N-fertilization on root architecture in *Pinus ponderosa*. Trees 19:43-50. WED-04-020

Two WED interns get Fisheries Society award for meeting's best student poster

Nancy Raskauskas and Stefanie Orlaineta, undergraduate interns at WED, received the best student poster award at the annual meeting of the American Fisheries Society's Oregon Chapter in February. Study design, data collection, and analysis for their poster, "Cool Hideaways: Use of Summer Temperature Refuges by Juvenile Coho Salmon in the West Fork Smith River," were conducted as part of their internship with the Division's Freshwater Habitat Project. Raskauskas is writing her senior honors thesis on the study for her bachelor's degree at Oregon State University. The west fork of the Smith River, in coastal Oregon, has summer temperatures that exceed water quality criteria, but still supports a robust population of coho salmon. Pockets of cooler water around tributary junctions, spring seeps, or in deep pools can provide thermal refuges where fish congregate to reduce their

Nancy Raskauskas, left, and Stefanie Orlaineta with their poster.

exposure to stressful temperatures. The two students mapped the distribution of the cool refuges during summer 2003, and monitored coho use of refuges and growth in relation to stream temperature during summer 2004. These data, combined with other data being collected for the Freshwater Habitat Project, will be used to identify factors limiting salmon recovery in coastal Oregon. (Contact: J.P. Baker 541-754-4517; baker.joan@epa.gov)

New tools for identifying optimal land management strategies

Land managers often need to know how to determine the greatest economic benefit that can be obtained by potential tradeoffs. For example, how much timber can be harvested without causing unacceptable impacts to wildlife? Resource economists and statisticians have collaborated with WED Ecologist Nathan Schumaker to develop computer modeling techniques that can produce quantitative answers. By combining biological and economic models they mathematically predicted strategies that best optimize both results – an outcome that achieves the maximum for each objective without harming a competing one. In an article in the *Journal of Environmental Economics and Management*, the researchers demonstrate their method by projecting timber production and species conservation on a forested landscape over a 100-year period.

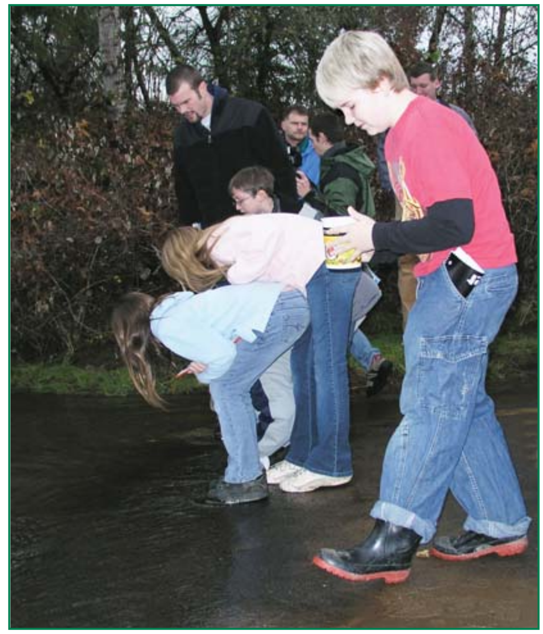
Their study used PATCH, (Program to Assist in Tracking Critical Habitat) developed by Dr. Schumaker. PATCH enables scientists to predict how wildlife populations might be affected by changes in land use. (Contact N.H. Schumaker, 541-754-4658; schumaker.nathan@epa.gov)

Reference: Nalle, D.J., C.A. Montgomery, J.L. Arthur, S. Polasky, and N.H. Schumaker. 2004. Modeling joint production of wildlife and timber. J. Environ. Econ & Mgt. 48:997-1017. WED-03-069

Bringing the complexities of salmon science to elementary school children

Ian Courter, a graduate student at Oregon State University (OSU) and EPA student volunteer at WED, is teaching elementary school children the biology and politics of salmon recovery. Under a National Science Foundation fellowship aimed at providing quality science education at rural schools, Courter is giving young students hands-on experience with the complexities of restoring salmon to Pacific Northwest rivers and streams.

In their classroom at Cascades Elementary School in Lebanon, a small city in Oregon's Willamette Valley, Courter's students hatched salmon from eggs, raised them to the proper size, and released them in the nearby South Santiam River. Eventually, they hope to see some salmon from their classroom hatchery return as spawning adults. Salmon eggs and incubator equipment were provided by the Oregon Department of Fish and Wildlife, local businesses, and WED. Courter is a student of Robert Lackey, Senior Fisheries Biologist at WED who serves as courtesy and adjunct professor, respectively, in OSU's departments of Fisheries & Wildlife and Political Science. In addition to Lackey, a number of WED scientists, including Joe Ebersole, EPA postdoctoral fellow, and Suzanne Pierson, Geographic Information Systems expert with Indus Corporation, provide technical advice for Courter. (Contact: R.T. Lackey 541-754-4607; lackey.robert@epa.gov)



The children, including Kolby Peterson, released the salmon they had hatched into the South Santiam River at a park in Lebanon, Oregon.

Ian Courter, a student volunteer at WED, explains a classroom salmon incubator to sixth graders. Inside (not visible) is a tank and water filtration system. A vending machine company donated a cold food machine that became the incubator's cooling system.

EPA scientists consult with Russian colleagues on risk of genetically engineered plants

Jay Reichman, NHEERL postdoctoral fellow at the WED, and two other EPA scientists visited Russia in May to collaborate with Russian scientists on development of tests for risk assessment of genetically engineered plants. The objective of the project, a partnership with the Research Centre for Toxicology and Hygienic Regulation of Biopreparations at the Ministry of Health of the Russian Federation, is development of tools for use in ecological and toxicological risk assessments of plants that have been genetically altered to produce insecticides. Bob Frederick, of EPA's National Center for Environmental Assessment (NCEA), in Washington, D.C., is the EPA technical manager for this project. Assisting is David Lee, American Association for the Advancement of Science Fellow at NCEA.

With funding provided by the Department of State, EPA's Office of Research and Development (ORD) is establishing this partner project under the International Science and Technology Center (ISTC), which was established by international agreement in November 1992 as a nuclear nonproliferation program. The ISTC coordinates efforts of numerous governments, international organizations, and private sector industries, to provide scientists who have been employed in weapons development in Russia and the Commonwealth of Independent States new opportunities in international partnership.

The ORD scientists' visit to laboratories in Serpukhov, Russia, is expected to begin the process of refining and targeting the research direction and to exchange information about EPA's research on risks of genetically engineered plants. The three year project will result in a targeted research program by the Russian scientists that complements work being done in the U.S. and around the world. ORD scientists will benefit from additional approaches and methods developed by their counterparts in Russia, and the Agency will benefit from any additional tools that are developed. The project will provide an opportunity to inform scientists in Russia about state of the art research being conducted by the EPA on genetically engineered plants. (Contact: R.J. Frederick at NCEA, 202-564-3207; frederick.bob@epa.gov)

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